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A Simple Computer Model for Evaluating Coastal Inlet Hydraulics

by
William N. Seelig

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A computer program for the prediction of coastal inlet velocities, discharge, and bay level fluctuations is presented. Two examples are given to demonstrate the numerical model. The computer documentation is included as an appendix, and the card deck may be obtained at CERC.

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PREFACE

This report describes a method for estimating inlet velocities, discharge, and bay levels based on the numerical model of Seelig, Harris, and Herchenroder (in preparation, 1977). This method for predicting inlet hydraulics is not discussed in the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975). The work was carried out under the General Investigation of Tidal Inlets (GITI) of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by William N. Seelig, Research Hydraulic Engineer, under the general supervision of Dr. R.M. Sorensen, Chief, Coastal Structures Branch.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

JOHN H. COUSINS
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.39	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.8532	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.1745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

SYMBOLS AND DEFINITIONS

A_{bay}	bay surface area (square feet)
A_o	bay surface area at datum (square feet)
C1, C2	coefficients to evaluate Manning's n (dimensionless)
d_{bay}	depth of bay (feet)
d_{max}	maximum water depth in inlet (feet)
D	stillwater depth (feet)
g	acceleration of gravity (32.2 feet per second squared)
h_b	water level in bay (feet)
h_s	water level in sea (feet)
L_{bay}	length of bay (feet)
L_{in}	length of inlet (feet)
T_F	forcing wave period (seconds)
t	time step used in model (seconds)
β	bay surface area variation parameter (dimensionless)

A SIMPLE COMPUTER MODEL FOR EVALUATING COASTAL INLET HYDRAULICS

by
William N. Seelig

I. INTRODUCTION

This report describes a method for estimating coastal inlet velocities, discharge, and bay levels using the simple numerical model of Seelig, Harris, and Herchenroder (in preparation, 1977)[1]. The model can be used for sea level fluctuations caused by astronomical tides, storm surges, seiches, or tsunamis. A digital computer program is used because of the large number of computations. A run on a CDC 6600 computer generally costs less than $5 for a tidal cycle.

II. PREDICTING INLET HYDRAULICS

1. Systems Modeled with Computer Program.

An inlet-bay system consists of a "sea" (e.g., ocean or lake) connected to a "bay" by one or more inlets (Fig. 1). The computer model will predict bay levels, inlet velocities, and discharge as a function of time given the geometry of the system and the water level fluctuations in the sea. It is assumed that the sea is much larger than the inlet and bay and that the bay is large compared to the inlet.

The model is designed for systems where the bay water level rises and falls uniformly throughout the bay. This occurs when the wavelength in the bay is much longer than the longest axis of the bay:

$$T_F \sqrt{g d_{bay}} \gg L_{bay} , \tag{1}$$

where

T_F = forcing wave period

g = acceleration of gravity

d_{bay} = depth of bay

L_{bay} = length of bay

2. Procedures for Use of Computer Program.

Step 1. Evaluate the inlet geometry by using maps, charts, hydrographic surveys, and dredging records to determine the depth of water throughout the inlet. The side slope of the inlet at mean water level

[1]SEELIG, W.N., HARRIS, D.L., and HERCHENRODER, B.E., "A Spatially Integrated Numerical Model of Inlet Hydraulics," GITI Report 14, U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., and U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. (in preparation, 1977).

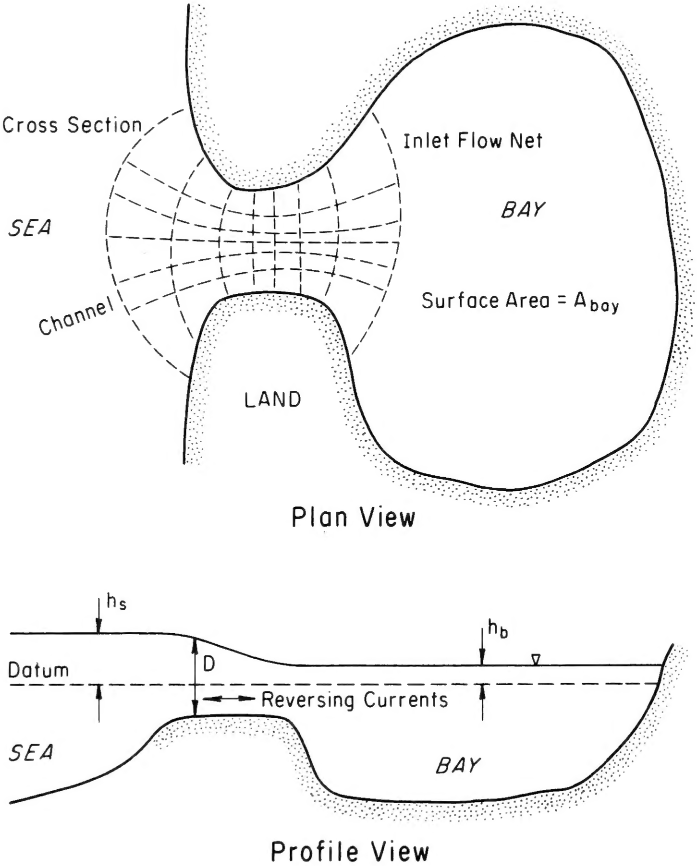


Figure 1. Inlet-bay system.

should also be measured. Whenever possible, obtain this information for the time of interest because inlets frequently change shape, especially during major storms.

Step 2. Construct a flow net (series of cross sections and channels) for the inlet to represent the model grid (Fig. 1). The flow net and inlet discharge are used to determine bottom friction throughout the inlet. The flow net is drawn by approximating the average path (channel) that water follows during ebb flow and floodflow. Channel boundaries are drawn along these paths for up to seven channels. A simple inlet with constant depth and width may be modeled with one or two channels. Complex inlets require approximately three to seven channels. Channels should have the smallest spacing in deep parts of the inlet where flow will be highest. Up to eight cross sections should then be drawn perpendicular to the channels. The first cross section in the sea and the last cross section in the bay should have cross-sectional areas 10 times larger than the minimum cross-sectional area. Cross sections should be drawn with the narrowest spacing near the minimum cross-sectional area section where friction in the inlet will be high.

Step 3. Measure the surface area of the bay at the mean water level, A_o, from charts or aerial photos. For most bays the surface area changes as the bay water level rises and falls because sections are flooded at high water levels. If the bay area change is significant, a bay area variation parameter, β, is used to account for area of the bay, A_{bay}, at any water level in the bay, h_b, using the relation:

$$A_{bay} = A_o(1 + \beta h_b) \ , \tag{2}$$

where A_o is the bay surface area at datum, usually mean low water (MLW), mean sea level (MSL), or mean water level (MWL).

Step 4. Specify the seawater level fluctuation as a function of time for the period of interest. Tide tables will give an estimate of the astronomical tide. Water levels can also be measured by a tide gage and stilling well (Seelig, 1977)[2]. Corps of Engineers and National Oceanic and Atmospheric Administration (NOAA) gages located at numerous points along the coast may also provide the desired water level information. In this computer program either the tide may be expressed as a sinusoidal wave with a period and amplitude or the levels may be described by instantaneous sea level measurements at a constant sampling rate.

Step 5. Determine the time step of input to the model for use in computations. As a lower limit, the time step, Δt, should be:

$$\Delta t = \frac{L_{in}}{\sqrt{g d_{max}}} \ , \tag{3}$$

---

[2]SEELIG, W.N., "Stilling Well Design for Accurate Water Level Measurement," TP 77-2, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Jan. 1977.

where L_{in} is the length of the inlet and d_{max} is the maximum water depth in the inlet. A longer time step can be used for most tidal inlets, and as an upper limit, the time step should be one-hundredth of the forcing wave period.

Step 6. Document all input data using the computer format shown in the appendix. As a first estimate, set the flood and ebb entrance and exit loss coefficients to equal one (CDF = 1.0 and CDE = 1.0). As a first approximation, Manning's n can be evaluated by the relation:

$$n = C1 - C2\ D \ , \tag{4}$$

where D is the local inlet stillwater depth. For depths greater than 4 feet and less than 30 feet, C1 = 0.03777 and C2 = 0.000667; for depths less than 4 feet, C1 = 0.0550 and C2 = 0.005. The n for each grid may be different if C2 $\neq$ 0.

Step 7. For use with periodic forcing, run the program for several sinusoidal cycles having the period and amplitude of the long wave of interest to approximate the hydraulic characteristics of the inlet-bay system. A sinusoidal tide is specified in the model by giving the forcing period, T, in hours and the wave amplitude, A_o, in feet, on card type 3 and by setting NPTS = 0 on card type 8 of input to the program INLET. Set ITABLE = 1 to obtain tables of instantaneous hydraulics at points throughout the water level cycle and set IPLOT = 1 to obtain a plot of predicted inlet velocities and discharge at sequential bay levels. These outputs will indicate the importance of the terms in the equation of motion describing water motion in the inlet. If temporal acceleration is small during most of the water level cycle, then startup transients will be small and the first or second cycle will contain little transient effect (NCYCLES = 1 or 2 in input data). However, if temporal acceleration is significant during more than 25 percent of the cycle, approximately four cycles of model operation are required to eliminate startup transient effects (NCYCLES = 4). For aperiodic use such as with storm surges or rapidly varying wave size (e.g., tsunamis), run the model for the water level for approximately 10 hours before the time of interest to build up initial conditions in the model similar to the prototype.

Step 8. Calibrate the computer model by varying Manning's n or flood- and ebb-loss coefficients. The seawater level fluctuation can be specified as a sinusoidal wave or in terms of an equal time series. For an equal time series, start and stop the series when the seawater level is at zero so that one or more complete cycles are described. Use at least 20 points to describe each cycle. The sampling interval in minutes, TDEL, and the number of points, NPTS, must be specified on card type 8 and the water level data on card type 9.

The model is calibrated using short periods of field observations by first comparing observed and predicted mean water velocities, if available, at the minimum cross-sectional area region of the inlet. If the predicted velocities are higher or lower than observed, then the value

of n can be increased or decreased accordingly. When the computer model has been satisfactorily calibrated to predict inlet velocities, predicted bay water levels should be checked against measurements to assure that levels are being modeled correctly. If inlet velocities are not available, bay levels can be used to calibrate the model.

Step 9. If additional prototype data are available, these data should be used to verify that the model adequately predicts inlet and bay hydraulics.

Step 10. At this point the computer program is ready to use for prediction. Examples of the use of the computer program are presented in the following section. Input and output data, and computations are in U.S. Customary units.

III. EXAMPLES OF COMPUTER PROGRAM PREDICTION

1. Cabin Point Creek, Virginia.

Cabin Point Creek is a shallow natural tidal inlet that connects a bay to the lower Potomac River (Fig. 2) where the mean tidal range is approximately 1.5 feet.

In this example, the model was calibrated with prototype river and bay levels and the calibrated model was then used to predict inlet velocities, discharge, and bay level for a second inlet added to the system. The procedures for using the model are:

(a) The inlet cross section was measured (Fig. 3) on 24 May 1976, and is assumed to be representative of the 1,900-foot-long inlet.

(b) The inlet is modeled using a grid system of three channels and two identical cross sections (Fig. 3) at either end of the inlet.

(c) The bay area, A_o, measured from a 7½-minute U.S. Geological Survey (USGS) topographic map, was 3.5×10^6 square feet. For an increase in bay water elevation of 0.25 foot, the bay surface area increases approximately 5 percent because of marsh flooding. The bay area variation parameter, β, can be determined from this information using equation (2), rearranged as:

$$\beta = \frac{1}{h_b}\left(\frac{A_{bay}}{A_o} - 1\right) , \qquad (5)$$

or, in this case,

$$\beta = \frac{1}{0.25}(1.05 - 1) = 0.2$$

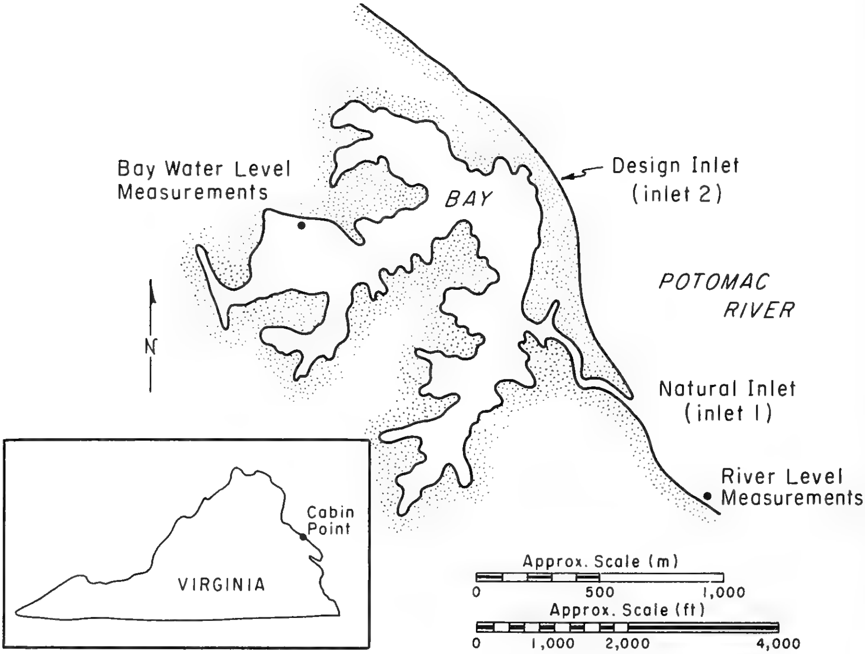


Figure 2. Cabin Point Creek, Virginia.

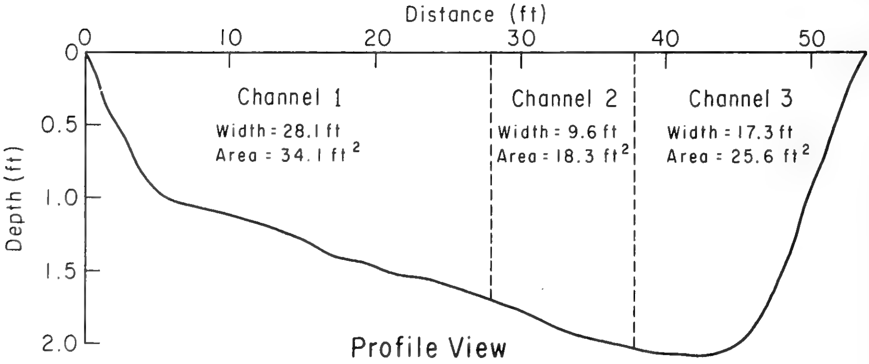


Figure 3. Cabin Point Creek cross section.

(d) River water levels were measured at 30-minute intervals using a stilling well located near the inlet mouth (Fig. 2).

(e) The time step was estimated as:

$$\Delta t = \frac{1900}{\sqrt{32.2 \times 2}} = 250 \text{ seconds}$$

(f) Loss coefficients were specified as CDF = CDE = 1.0, and Manning's n was estimated as n = 0.055 - 0.005 D (recommended for depths less than 4 feet).

(g) A preliminary computer run using a sinusoidal river tide showed that the inlet is controlled by friction effects and that temporal acceleration is not important.

(h) The model was then run using the measured river water levels to force the model (Fig. 4). It was determined that the model adequately predicted bay levels.

(i) No additional prototype data are available for verification of the model.

(j) The model is now available to use for predictions of inlet hydraulics. In this example, a second inlet (inlet 2), is being considered for this site, so the model is used to predict hydraulics for the system with two inlets (Fig. 2). Procedures (a) and (b) are repeated for the second inlet. In this case, the second inlet is modeled by one channel and two cross sections so that the inlet has a length of 300 feet, a width of 50 feet, and a depth of 4 feet. These inlet data are put into the computer format, added to the program deck for the natural inlet, and rerun to predict conditions for the proposed two-inlet system. The numerical model predicts that addition of the second inlet would increase the tidal range and the tidal prism in the bay and would cause water velocities in inlet 1 to decrease (see Table).

Table. Predicted Cabin Point Creek hydraulics.

Tide	24 and 25 May 1976	Model prediction for second inlet	
	Inlet 1	Inlet 1	Inlet 2[1]
Bay (range in ft)	0.36	1.49	1.49
Ebb (maximum velocity in ft/s)	-0.6	-0.3	-1.3
Flood (maximum velocity in ft/s)	0.9	0.3	1.7

[1]L = 300 feet, B = 50 feet, D = 4 feet.

NOTE: Tidal range in the sea is 1.49 feet.

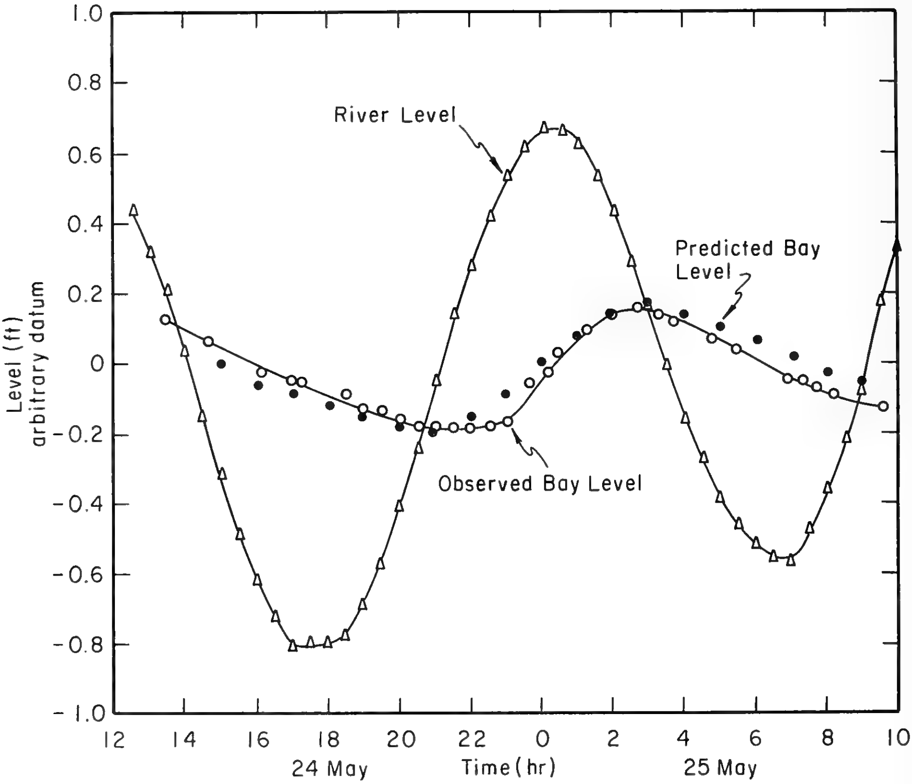


Figure 4. Cabin Point Creek sea and bay levels.

2. Pentwater Inlet, Michigan.

Pentwater Inlet is an example of a Great Lakes inlet controlled by vertical-walled jetties along the entire 2,000-foot channel (Fig. 5). Meteorologically generated seiches of Lake Michigan are the primary water level fluctuations causing reversing currents in the inlet. A model of Pentwater will be calibrated and used to estimate hydraulic response of the inlet to simultaneous lake seiching and river inflow. The procedures used in this modeling are:

(a) A hydrographic survey of the inlet is used to describe the inlet geometry.

(b) The inlet is modeled using one channel and six cross sections.

(c) The bay surface area, measured from a hydrographic chart, is 1.81×10^7 square feet. The bay area does not change with bay water level because the bay has steep-sided slopes, so $\beta = 0$.

(d) Lake Michigan water level measurements used to force the model were taken at 5-minute intervals on a tower located adjacent to Pentwater Inlet.

(e) The model time step used is:

$$\Delta t = \frac{2000}{\sqrt{32.2 \times 15}} = 90 \text{ seconds}$$

(f) Loss coefficients were specified as CDE = CDF = 1.0, and Manning's n was estimated by $n = 0.03777 - 0.000667\ D$ (recommended for depths greater than 4 feet and less than 30 feet).

(g) A preliminary run showed that temporal acceleration is an important term in the inlet equation of motion for Pentwater Inlet (Fig. 6). Therefore, several forcing cycles of model operation before the time of interest are necessary to eliminate transient terms due to startup conditions.

(h) The model is calibrated by using Lake Michigan levels to force the model. An initial run showed that predicted bay level fluctuations adequately modeled observed levels (Fig. 7).

(i) The model was not verified.

(j) The model was used to predict inlet velocities, discharge, and bay levels for a 2-hour forcing wave with an

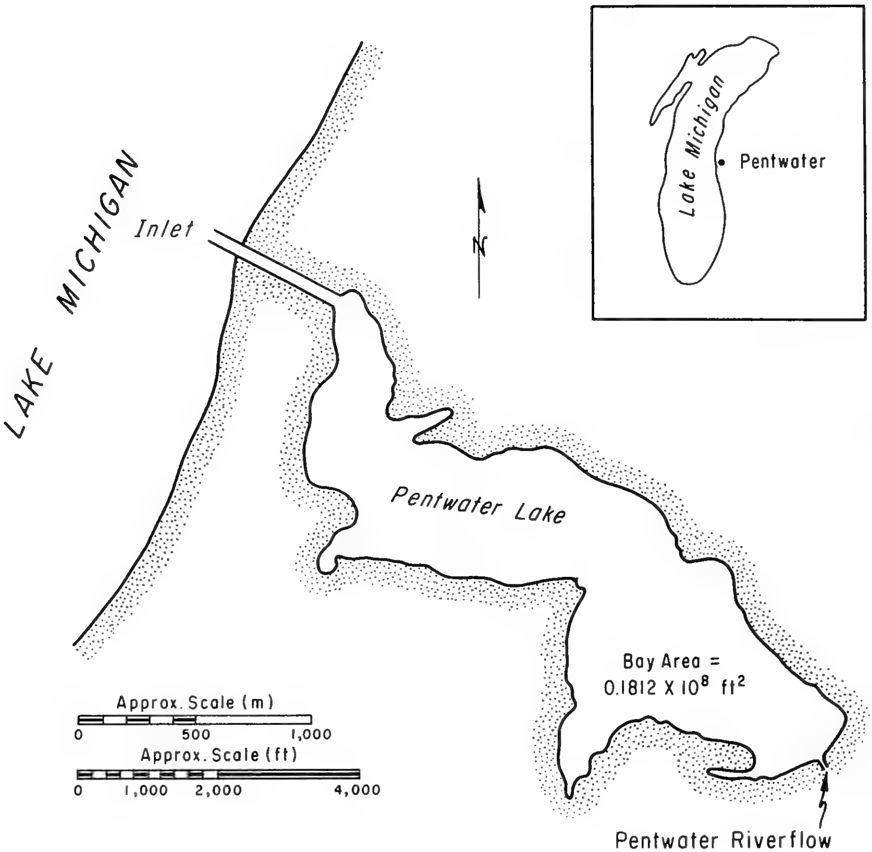


Figure 5. Pentwater Inlet, Michigan.

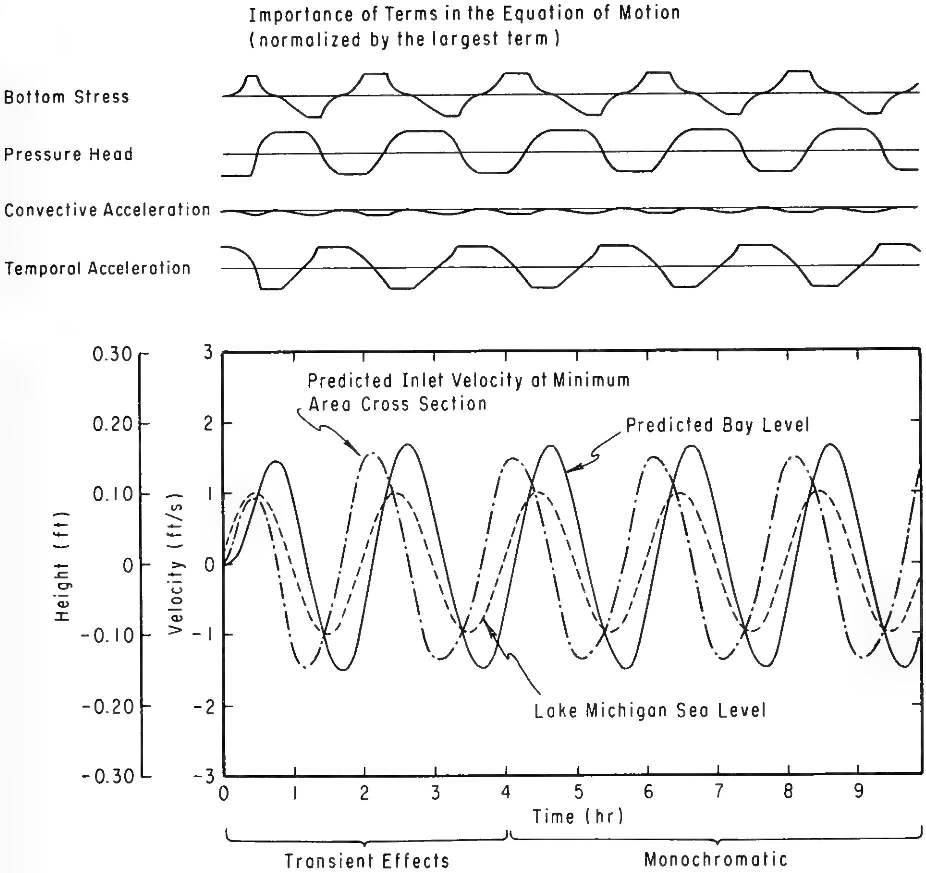


Figure 6. Pentwater Inlet model prediction of monochromatic forcing (for a 2-hour wave with a 0.1-foot amplitude).

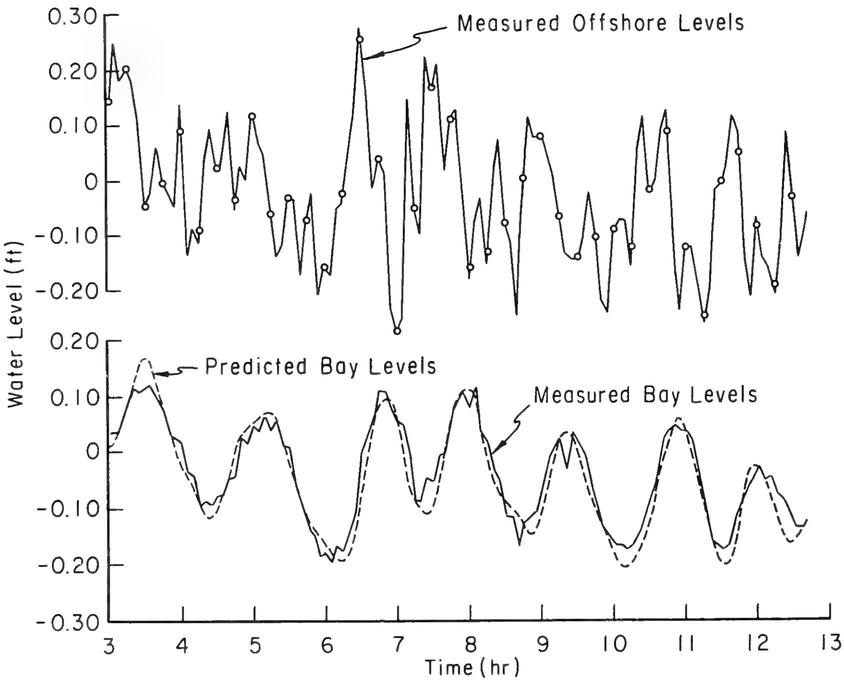


Figure 7. Pentwater Inlet model calibration.

amplitude of 0.10 foot and a discharge into Pentwater Lake of 2,800 cubic feet per second from the Pentwater River. The model predicted an average bay water surface elevation of 0.13 foot higher than the mean lake level, a bay water level fluctuation range of 0.25 foot, and a prism of water of 4.6×10^6 cubic feet caused by the seiche (Fig. 8). The inlet would always be in ebb flow due to river influence with a maximum velocity of -2.7 feet per second and a minimum velocity of -0.1 foot per second. Head, friction, and temporal and convective acceleration are important in the inlet equation of motion.

IV. SUMMARY

A computer program (INLET) based on a numerical model (Seelig, Harris, and Herchenroder, in preparation, 1977)[1] is presented for prediction of hydraulics where one or more inlets connect a bay to a sea. Two examples are given: (a) A tidal inlet forced by an astronomical tide where inlet channel friction is the dominant term in the equation of motion; and (b) a Great Lakes inlet with river inflow forced by lake seiching where head, friction, and temporal and convective accelerations are important at different points in the water level fluctuation cycle. The model can also be used for forcing other water level fluctuations, such as from storm surges or tsunamis.

Another computer program (INLET2) is available for more complex systems of interconnected inlets, bays, and seas. INLET2 is an expanded version of INLET. Documentation and computer card decks for INLET2 are available from the Automatic Data Processing Division (CERDP), Coastal Engineering Research Center (CERC).

Details on model development and application, including additional examples, are reported by Seelig, Harris, and Herchenroder (in preparation, 1977)[1].

[1]SEELIG, HARRIS, and HERCHENRODER, op. cit., p. 7.

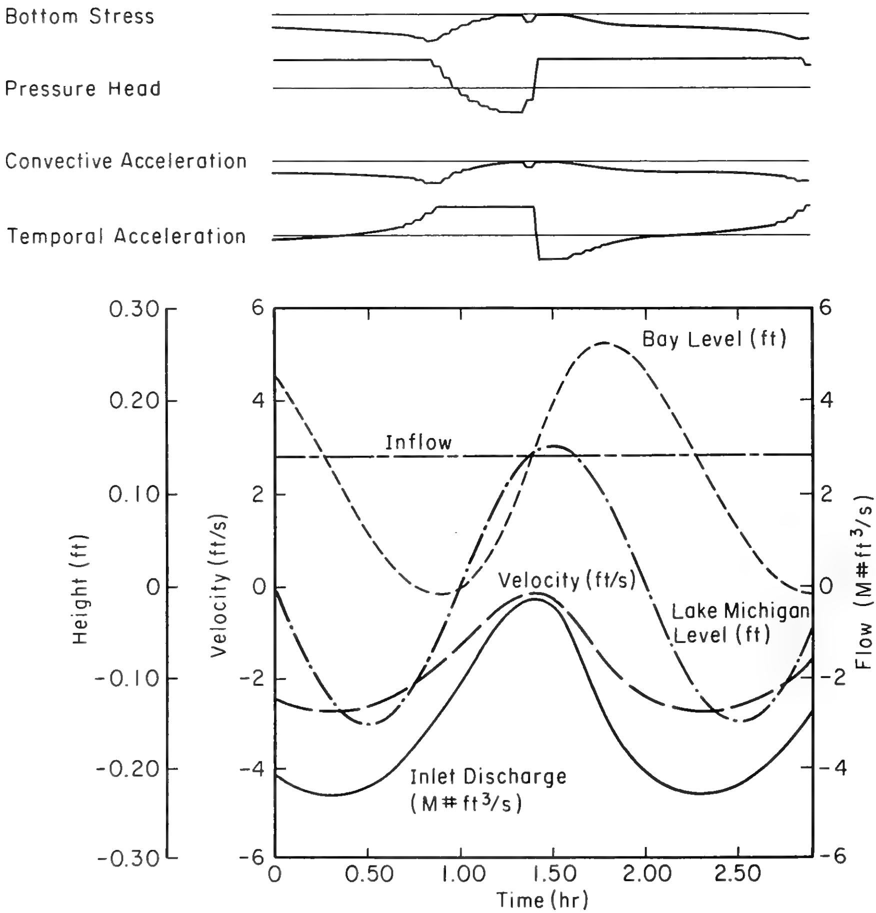


Figure 8. Predicted Pentwater Inlet velocities, discharge, bay levels, and relative magnitude of terms in the equation of motion.

APPENDIX

COMPUTER PROGRAM DOCUMENTATION (INLET)

1. Program Description.

The numerical model to predict inlet hydraulics is programed in FORTRAN for a CDC 6600 computer. The simultaneous differential equations are solved by a variable time step Runge-Kutta-Gill marching procedure. The organization of the computer program is shown in Figure A-1. A brief description of each routine follows:

INLET is the main routine which controls input-output and calls subroutines to execute a specific task. Figure A-1 summarizes control throughout the program. The program is organized to accept up to three inlets connecting the bay to the sea, up to seven channels for each inlet, and up to eight cross sections (seven grids long).

Subroutine HELM uses an iterative method of estimating the natural pumping period or Helmholtz period, T_H', for the inlet-bay system by neglecting friction in the inlet to give:

$$T_H' = 2\pi \sqrt{\frac{(L_{in} + L') A_{bay}}{gA_c}}$$

where L' is added inlet length due to radiation, and where L' is given by:

$$L' = \frac{-B}{\pi} \ln \left(\frac{\pi B}{\sqrt{gd}\ T_H} \right)$$

Subroutine RKGS is a routine to solve simultaneous differential equations. This subroutine was adapted from the scientific subroutine package.

Subroutine SETEQ evaluates the right-hand side of the equation of motion, one for each inlet, and the continuity equation between the inlet and bay for each step. This routine also evaluates the relative rank of the four terms in the equation of motion for flow in each inlet.

Subroutine LEVEL determines the water level in the grids at each time step. The routine interpolates the level between the sea and bay based on the relative amount of friction in each grid cell.

Subroutine TPWRTE writes hydraulic results from each time step on a tape or disc, so that this information can be used later by the output routines.

Subroutine TABLE outputs a table of instantaneous hydraulics each time the routine is called.

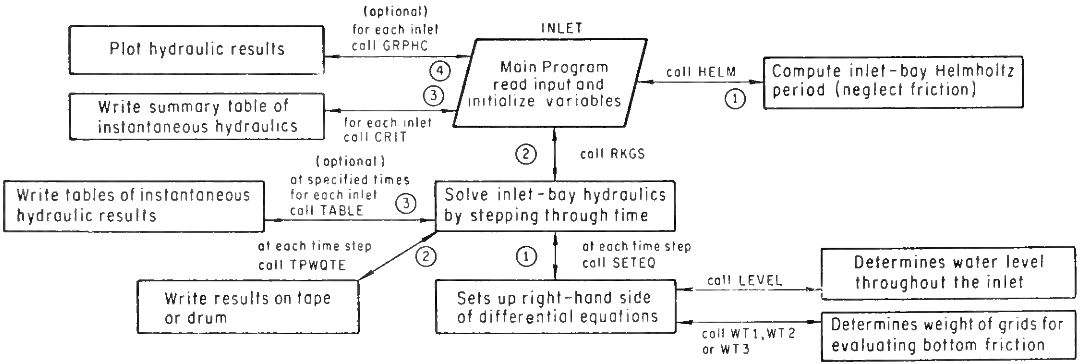


Figure A-1. Flow chart of the computer program INLET.

Subroutine SEA determines the water level in the sea as a function of time either for a given sine wave or by interpolating equal time-series data.

Subroutine WT1 determines the grid-weighting function by assuming that the flow is distributed across each section so that friction is minimized. This routine allows flow to cross channel boundaries, but assumes that this flow will be small, so the flow is neglected in the equation of motion. This weighting function is recommended for general use.

Subroutine WT2 is similar to WT1, except that flow is not allowed to cross channel boundaries and that flow is distributed in each channel so that friction is minimized.

Subroutine WT3 determines the weighting function so that flow is distributed equally in all grids. This is generally unrealistic, since it will be difficult to visually draw this grid system. However, this routine is useful since it provides an upper limit on frictional effects and therefore gives a lower limit of bay levels and inlet velocities. This weighting can be used to model simple geometry inlets where only one channel is used to represent the inlet.

Subroutine CRIT prints a table of critical instantaneous hydraulics (i.e., at high water, low water, maximum velocity, and maximum discharge). This table is determined by storing a summary of conditions for each time step, then scanning this list for critical values.

Subroutine GRPHC plots mean inlet hydraulics by scaling hydraulics in storage and plotting the time interval requested on a digital x-y pen plotter.

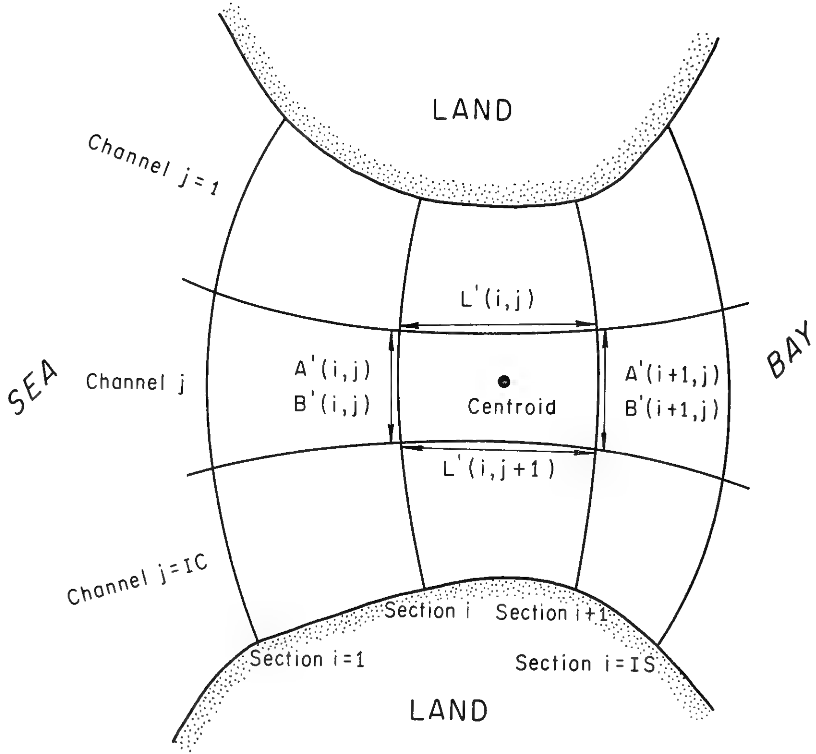
Subroutine READIN is used by GRPHC to read data in storage and scale values for plotting.

2. Program Input.

The computer program (INLET) requires the following input of one deck for each inlet-bay system:

Card type	Variables	Format	Description
1	ALABL1	4A10	first line of title
	ALABL2	4A10	second line of title
2		5I10, 2F10.5, I10	
	NINLET		number of inlets
	NCYCLES		number of cycles
	IPLOT		IPLOT = 1 for plot of results

Card type	Variables	Format	Description
	IWT		weighting type IWT = 1 flow distributed to minimize (1 in card col. 40)
	ITABLE		ITABLE = 1 for tables of instantaneous hydraulics
	C1, C2		Manning's n evaluated by: n = C1 - C2 * D; where D is still-water depth. If blank default values of C1 = 0.03777 and C2 = 0.000667 are assumed.
	ICONV		ICONV = 1 (1 in card col. 80)
3		3F10.5, E10.4, 3F10.5, 2F5.1	
	T		forcing period (hours)
	DELT		approximate time increment
	AO		forcing wave amplitude (feet)
	AB		bay area at datum (square feet)
	BETA		bay area variation parameter
	ZETA		inlet side slope D(z)/D(y)
	QINFLO		bay inflow from sources other than the inlet (cubic feet per second)
	CDF		an empirical flood-loss coefficient
	CDE		an empirical ebb-loss coefficient
4		2I10, F10.0	
	IC		number of channels
	IS		number of cross sections
	QINT		estimated inlet discharge at the time the model starts
5	(one card per section)	10X, 7F10.5	
	A'		cell cross-sectional areas at the ends of each cell at datum (square feet) (see Fig. A-2)
6	(one card per section)	10X, 7F10.5	
	B'		grid cell widths for the end of each cell (feet) (see Fig. A-2)



Cell characteristics

$$A(i,j) = \frac{A'(i,j) + A'(i+1,j)}{2}$$

$$B(i,j) = \frac{B'(i,j) + B'(i+1,j)}{2}$$

$$D(i,j) = A(i,j) / B(i,j)$$

$$L(i,j) = \frac{L'(i,j) + L'(i,j+1)}{2}$$

are applied at the cell centroid

Figure A-2. Cell input data.

Card type	Variables	Format	Description
7	(one less card than sections)	10X, 7F10.5	
	L'		lengths of the sides of cells (see Fig. A-2) (one less card than number of sections; one more value per card than the number of channels)

For card types 5 to 7, there will be one card for each cross section of the inlet. The first card will be for the first cross section, i.e., the section closest to the sea, and the last section is adjacent to the bay. The first value on each card will correspond to the first channel adjacent to land; the last value on each card will correspond to the last channel also adjacent to land (Fig. A-2).

For more than one inlet connecting the bay to the sea, repeat card types 3 to 7 for each additional inlet.

Card type	Variables	Format	Description
8	TDEL	34X, F6.2	water level sampling interval (minute)
	NPTS	6X, I3	number of sample points = 0 for no data
9	(optional--no cards if NPTS = 0 from card type 8)		
	Y		eight water level values per card, as many cards to include NPTS points; start the model at a time when the sea level is zero. Use 25 or more points per forcing cycle for best results; i.e., levels at 30- or 15-minute intervals for a 12-hour tide.
10	(optional--two plot cards, first card used only if IPLOT = 1 on card type 1)		
		8F10.5,/,3F10.5, I10	
	XO		starting time of plot (hours)
	XF		ending time of plot (hours)
	SCALX		time scale (hours per inch)
	YLO		minimum value of water levels (feet)
	YL		overall height of plot (inches)
	YLSCAL		scale of water level height (feet per inch)

Card type	Variables	Format	Description
	YRO		minimum flows (thousand cubic feet per second)
	YRSCAL		scale of flows (thousand cubic feet per second per inch)
Second card			
	YVO		minimum velocity (feet per second)
	YVSCAL		scale of velocities (feet per second per inch)
	SCALE		scale factor for total plot size
	IQ		IQ = 0 for no plot of inlet discharge
11	If a plot is requested, repeat card types 8 and 9 for observed bay levels to compare with predictions (card type 8 required; use NPTS = 0 for no observed bay levels). Only one set of card types 10 and 11 will be required for plotting even though the system modeled may have more than one inlet.		
12	End of file card.		

The inlet data for a computer run of Masonboro Inlet, North Carolina, are shown in Figure A-3.

3. Program Output.

The types of output include: (a) A summary table of grid dimensions, input parameters, and the Helmholtz period of the system estimated assuming there is no friction in the inlet; (b) (optional) summary tables of instantaneous inlet hydraulics; (c) (optional) a pen plot of inlet hydraulics; and (d) a table summarizing critical points throughout model operation, such as high water, low water, point of maximum discharge, and maximum velocity. Samples of input and output for the Masonboro Inlet run are given in Figures A-4, A-5, and A-6.

4. Computer Program.

A listing of the computer program (INLET) follows the sample output. The program was written in FORTRAN IV for a CDC 6600 computer with plotter. Control cards, plotting instructions, and file controls may have to be changed for other computers. If no plotter is available, the subroutine GRPHC and the call to the subroutine in the main program may be removed.

```
MASONBORO 1969
CDF=2.
          1          1          1          2          1    0.        0.              1
  25.0      200.      2.15      .20000E+09  0.2        0.0133      0.        2.     0.
          4          7  -20000.
A1          28280.    5510.      4570.     2420.
A2           9725.    7885.      5680.     2140.
A3           3061.    5650.      5625.     3700.
A4            940.    2525.     10030.     5285.
A5            500.    3036.      5079.     4080.
A6           3770.    5850.      5330.     3925.
A7           4390.    6610.      8400.     4000.
B1           3000.     680.       200.       90.
B2           1320.    1400.       310.      100.
B3            500.    1380.       280.      260.
B4            350.     430.       450.      500.
B5            280.     150.       280.      350.
B6            840.     890.       420.      460.
B7            980.     670.       670.      260.
L1            850.     900.      1000.     1000.     1000.
L2            750.     950.      1000.     1000.     1000.
L3            440.     550.       900.     1050.     1200.
L4            500.     700.       850.      900.      900.
L5            400.     800.       950.      600.      200.
L6           2600.    2100.      2100.     3600.     3400.
GAGEO 9/12/69 MASONBORO    DELT=      30. NUM=  50
 -1.39     -1.60     -1.65     -1.60     -1.38     -0.98     -0.60     -0.08
  0.34      0.82      1.29      1.70      2.08      2.33      2.48      2.50
  2.41      2.22      1.91      1.50      1.        0.50      0.       -0.50
 -0.98     -1.32     -1.55     -1.62     -1.60     -1.44     -1.03     -0.69
 -0.20      0.36      0.93      1.40      1.74      2.10      2.31      2.49
  2.48      2.29      1.97      1.56      1.16      0.6       0.1      -0.4
  -0.9      -1.3
    0.       22.        2.       -3.        6.        1.      -60.       20.
   -6.        2.        1.                0
NO BAY
  EOR
```

Figure A-3. Sample of input data for a computer run of Masonboro Inlet, North Carolina.

```
------------------------
      MASONBORO 1969
      TEST

   CONTROL CARDS
        1          1          0          2          1   0.00000   0.00000
 25.00000 200.00000   2.15000 .2000E+09    .20000    .01330   0.00000  2.0  0.0

   SUMMARY OF INLET GRID CHARACTERISTICS
            INLET NUMBER  1
      =          6

SECTION  1
    CHANNEL =         1          2          3          4
    AREA(FT2)   19002.5     6697.5     5125.0     2280.0
    WIDTH(FT)    2160.0     1040.0      285.0       95.0
    DEPTH(FT)      8.80       6.44      17.98      24.00
    LEN(FT)       875.0      950.0     1000.0     1000.0
    N             .0319      .0335      .0258      .0218

SECTION  2
    CHANNEL =         1          2          3          4
    AREA(FT2)    6402.5     6767.5     5652.5     2920.0
    WIDTH(FT)     910.0     1390.0      295.0      180.0
    DEPTH(FT)      7.04       4.87      19.16      16.22
    LEN(FT)       850.0      975.0     1000.0     1000.0
    N             .0331      .0345      .0250      .0269

SECTION  3
    CHANNEL =         1          2          3          4
    AREA(FT2)    2010.0     4087.5     7827.5     4492.5
    WIDTH(FT)     425.0      905.0      365.0      400.0
    DEPTH(FT)      4.73       4.52      21.45      11.23
    LEN(FT)       495.0      725.0      975.0     1125.0
    N             .0346      .0348      .0235      .0303

SECTION  4
    CHANNEL =         1          2          3          4
    AREA(FT2)     720.0     2780.5     7554.5     4682.5
    WIDTH(FT)     315.0      290.0      365.0      445.0
    DEPTH(FT)      2.29       9.59      20.70      10.52
    LEN(FT)       600.0      775.0      875.0      900.0
    N             .0362      .0314      .0240      .0308

SECTION  5
    CHANNEL =         1          2          3          4
    AREA(FT2)    2135.0     4443.0     5204.5     4002.5
    WIDTH(FT)     560.0      520.0      350.0      405.0
    DEPTH(FT)      3.81       8.54      14.87       9.88
    LEN(FT)       600.0      875.0      775.0      400.0
    N             .0352      .0321      .0279      .0312

SECTION  6
    CHANNEL =         1          2          3          4
    AREA(FT2)    4080.0     6230.0     6865.0     3962.5
    WIDTH(FT)     910.0      780.0      545.0      360.0
    DEPTH(FT)      4.48       7.99      12.60      11.01
    LEN(FT)      2350.0     2100.0     2850.0     3500.0
    N             .0348      .0324      .0294      .0304
FORCING PERIOD=  25.00 HOURS
THELM(APPROX)=    3.17 HOURS
TF/TH=            7.88
INLET LENGTH  ADDED LENGTH
   1 4622.5  1749.4

   TDEL, MIN=   30.00    NPTS=   50

  -1.39 -1.60 -1.65 -1.60 -1.38  -.98  -.60  -.08   .34   .82  1.29  1.70  2.08  2.33  2.48  2.50
   2.41  2.22  1.91  1.50  1.00   .50  0.00  -.50  -.93 -1.32 -1.55 -1.62 -1.60 -1.44 -1.03  -.69
   -.20   .36   .93  1.40  1.71  2.10  2.31  2.44  2.46  2.29  1.97  1.56  1.16   .60   .10  -.40
   -.90 -1.30
```

Figure A-4. Sample output from INLET (summary table for Masonboro Inlet input data).

```
------------------------------
   TIME. HOURS =    6.000    DELT. SEC =  400.00

         INLET  1
         SEA LEVEL.FT=    2.08
         BAY LEVEL.FT=    1.23
         DISCHARGE.CFS= .5481E+05
         BAY AREA= .2493E+09 FT2
CHANNEL         SECTION 1        2         3         4         5         6         7      FRICTION
       FRIC            .04       .06       .07       .42       .11       .31
  1                                                                                         .12
  1   LEVEL           2.08      2.08      2.06      1.70      1.32      1.26
  1   V(FPS)           .12       .33       .94      2.14       .96       .53
  1   Q(CFS)         2802.     2802.     2802.     2802.     2802.     2802.
  1   WEIGHT           .05       .05       .05       .05       .05       .05
  1   FRIC             .00       .00       .00       .10       .01       .01
  2                                                                                         .19
  2   LEVEL           2.06      2.02      1.94      1.66      1.39      1.29
  2   V(FPS)          1.01       .93      1.52      2.71      1.73      1.24
  2   Q(CFS)         8993.     8993.     8993.     8993.     8993.     8993.
  2   WEIGHT           .16       .16       .16       .16       .16       .16
  2   FRIC             .01       .01       .02       .10       .02       .03
  3                                                                                         .46
  3   LEVEL           2.06      2.00      1.95      1.83      1.67      1.42
  3   V(FPS)          5.40      4.94      3.63      3.77      5.35      4.07
  3   Q(CFS)        31238.    31238.    31238.    31238.    31238.    31238.
  3   WEIGHT           .57       .57       .57       .57       .57       .57
  3   FRIC             .03       .03       .02       .11       .07       .20
  4                                                                                         .23
  4   LEVEL           2.07      2.04      1.98      1.75      1.54      1.37
  4   V(FPS)          4.60      3.50      2.20      2.13      2.52      2.62
  4   Q(CFS)        11772.    11772.    11772.    11772.    11772.    11772.
  4   WEIGHT           .21       .21       .21       .21       .21       .21
  4   FRIC             .00       .01       .02       .10       .01       .08
  TEMP ACC=      .6 CONV ACC=    32.4 HEAD= -100.0 FRIC=    67.0
  MEAN VELOCITY AT THE MINIMUM AREA SECTION=   2.97 FT/SEC  AMIN= 18.29.73 FT2
------------------------------
```

Figure A-5. Sample output from INLET (summary table of instantaneous hydraulics for Masonboro after 6 hours of model time).

SUMMARY TABLE OF HYDRAULICS INLET 1

TIME HRS	HS FT	INFLOW KCFS	HH FT	VEL FPS	Q KCFS
.334	-1.506	0.000	-.239	-3.861*	-55.160*
1.056	-1.650*	0.000	-.951	-2.919	-39.568
2.167	-1.303	0.000	-1.562*	.053	.683
3.834	.155	0.000	-.541	2.463*	37.947
3.945	.245	0.000	-.456	2.481*	38.631
5.167	1.386	0.000	.516	2.922*	50.286
5.389	1.568	0.000	.698	2.940*	51.646
5.500	1.656	0.000	.788	2.945*	52.193
5.611	1.744	0.000	.878	2.946*	52.650
5.723	1.834	0.000	.967	2.957*	53.252
5.834	1.922	0.000	1.056	2.968*	53.684
5.945	2.005	0.000	1.145	2.976*	54.441
6.056	2.080	0.000	1.234	2.974*	54.806
6.167	2.146	0.000	1.321	2.958*	54.889*
7.389	2.506*	0.000	2.147	2.154	41.977
8.389	2.296	0.000	2.462*	.086	1.714
10.611	.444	0.000	1.191	-3.308	-55.734*
10.667	.389	0.000	1.146	-3.337*	-55.713
10.778	.278	0.000	1.055	-3.362*	-55.607
10.889	.166	0.000	.962	-3.382*	-55.425
11.000	.055	0.000	.869	-3.398*	-55.177
11.111	-.056	0.000	.774	-3.411*	-54.870
11.223	-.168	0.000	.679	-3.422*	-54.519
11.334	-.279	0.000	.582	-3.429*	-54.126
11.445	-.391	0.000	.485	-3.433*	-53.680
11.556	-.500	0.000	.387	-3.435*	-53.170
11.667	-.611	0.000	.288	-3.430*	-52.608
11.778	-.723	0.000	.188	-3.427*	-52.037
11.889	-.831	0.000	.087	-3.420*	-51.412
12.000	-.933	0.000	-.014	-3.403*	-50.657
13.723	-1.625*	0.000	-1.418	-1.764	-22.758
14.445	-1.495	0.000	-1.665*	-.073	-.923
15.389	-.812	0.000	-1.245	1.880*	25.949
17.278	1.153	0.000	.185	2.994*	50.979
17.389	1.257	0.000	.283	3.020*	52.008
17.500	1.354	0.000	.382	3.036*	52.865
17.667	1.484	0.000	.526	3.089*	53.680*
17.778	1.559	0.000	.625	3.002*	53.685
17.834	1.595	0.000	.672	3.004	53.720*
17.889	1.630	0.000	.719	3.033*	53.719
18.056	1.740	0.000	.858	2.994	53.442*
18.111	1.780	0.000	.904	2.973*	53.468
18.223	1.864	0.000	.994	2.965*	53.749
18.334	1.949	0.000	1.083	2.967*	54.204
18.445	2.030	0.000	1.172	2.969*	54.648
18.556	2.100	0.000	1.260	2.962	54.883*
19.778	2.508*	0.000	2.099	2.267	44.163
20.723	2.196	0.000	2.416*	-.016	-.312
21.778	1.390	0.000	1.904	-2.904*	-52.628*
21.889	1.305	0.000	1.827	-2.921*	-52.545
22.000	1.211	0.000	1.750	-2.942	-52.477*
22.778	.373	0.000	1.157	-3.394*	-56.639*
22.889	.264	0.000	1.064	-3.415*	-56.478
23.000	.155	0.000	.970	-3.429*	-56.184
23.111	.044	0.000	.876	-3.440*	-55.836
23.223	-.067	0.000	.780	-3.449*	-55.460
23.334	-.178	0.000	.684	-3.456*	-55.044
23.445	-.289	0.000	.587	-3.459*	-54.588
23.556	-.400	0.000	.489	-3.461*	-54.092
23.667	-.513	0.000	.390	-3.461*	-53.574
23.778	-.628	0.000	.290	-3.463*	-53.063
23.889	-.741	0.000	.189	-3.462*	-52.518
24.000	-.849	0.000	.087	-3.454*	-51.870
24.111	-.951	0.000	-.015	-3.435*	-51.063
24.223	-1.052	0.000	-.117	-3.409*	-50.167
25.000	-1.390*	0.000	-.855	-2.599	-35.948

* CRITICAL POINT VALUE

Figure A-6. Sample output from INLET (table of critical points for the model time: high water, low water, etc., for Masonboro Inlet).

Listing of the computer program INLET.

```
      PROGRAM INLET(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE9,TAPE10,
     1 TAPE3,PUNCH=TAPE3)
C PROGRAM NUMBER 720X6R16S0 (INLET) ANALYSES AND PREDICTS INSTANEOUS INL
C HYDRAULICS USING A LUMPED PARAMETER SCHEME (SEE SEELIG, HARRIS AND
C HERCHENRODER, 1976, (A GENERALIZED LUMPED PARAMETER MODEL OF INLET
C HYDRAULICS(, A DRAFT CERC REPORT)
      REAL L,LENGTH,LIN,LX,N,NX
      COMMON/NUM5/NI,G,NINLET,ICH(3),ISE(3),QA,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ARAY,LENGTH(3)
      COMMON/NUM1/Y(5),DERY(5),X,NT,IWT,ZETA,HH
      COMMON/NUM2/BX(3,7,7),DX(3,7,7),HX(3,7,7),WX(3,7,7),LX(3,7,7),NX(3
     1,7,7)
      COMMON /NUM3/A0,T,AR,BETA
      COMMON/NUM4/RNK(3,4)
      DIMENSION CORL(3)
      DIMENSION ALABL1(4),ALABL2(4),IBUF(1000),NUMBER(20)
 3370 CONTINUE
      DO 2193 II=1,3
 2193 QX(II)=1.
C   G= ACCELERATION OF GRAVITY
      G=32.2
      DO 1211 I=1,20
 1211 NUMBER(I)=I
      WRITE(6,2937)
 2937 FORMAT(//,1X,(-------------------------()
      READ(5,1167) (ALABL1(I),I=1,4)
      READ(5,1167) (ALABL2(I),I=1,4)
 1167 FORMAT(4A10)
      WRITE(6,1168) (ALABL1(I),I=1,4)
      WRITE(6,1168) (ALABL2(I),I=1,4)
 1168 FORMAT(8X,4A10)
      WRITE(6,1268)
 1268 FORMAT(/,5X,(CONTROL CARDS()
C READ CONTROL CARDS
C
      READ(5,1011) NINLET,NCYCLES,IPLOT,IWT,ITABLE,C1,C2
      WRITE(6,1012) NINLET,NCYCLES,IPLOT,IWT,ITABLE,C1,C2
 1011  FORMAT(5I10,2F10.5)
 1012 FORMAT(1X,5I10,2F10.5)
C  NINLET=THE NUMBER OF INLETS
C  NCYCLES= NUMBER OF TIDAL CYCLES
C  IPLOT  (1 FOR A PLOT OF MEAN HYDRAULICS, 0 FOR NO PLOT)
C IWT IS A PARAMETER DESCRIBING THE TYPE OF WEIGHTING DESIRED
C  IWT=1 FOR FLOW WEIGHTING TO ACHIEVE MINIMUM FRICTION
C  IWT=2 FOR WEIGHTING FOR MINIMUM FRICTION WITH NO FLOW ACROSS CHANNELS
C  IWT=3 FOR EQUAL FLOW IN ALL GRIDS TO GIVE MAXIMUM FRICTION
C ITABLE=1 FOR A TABLE OF OUTPUT
C  C1,C2  N=C1-C2 * D.  IF C1 AND C2 ARE ZERO THE MASCH VALUES OF
C  C1 =.03777 AND C2=.000667 ARE USED
      IF(C1.EQ.0.0.AND.C2.EQ.0.0) C2= 0.000667
      IF(C1.EQ.0.) C1=0.03777
C
```

```
 1     FORMAT(8I10)
       READ(5,111) T,DELT,A0,AB,BETA,ZETA,QINFLO
       WRITE(6,111) T,DELT,A0,AB,BETA,ZETA,QINFLO
 111   FORMAT(3F10.5,E10.4,4F10.5)
C    T=TIDAL PERIOD, HRS (LATER CONVERTED TO SECONDS)
C    DELT=ESTIMATED TIME STEP,SEC
C    A0= SEA TIDAL AMPLITUDE,FT
C    AB= BAY AREA AT THE DATUM, SQUARE FEET
C    BETA= BAY AREA VARIATION PARAMETER ( D(AB)/D(HB))
C    ZETA= CHANNEL SLOPE (D(Y)/D(X))
C    QINFLO= INFLOW INTO THE BAY FROM OTHER SOURCES (FT3/SEC)
C
       END=T*NCYCLES*3600.
       IF(ZETA.LE.0.)ZETA=1.0E25
       NT=0
C
C READ IN INFORMATION OF EACH INLET
       DO 1110 NI=1,NINLET
       IUNIT=8+NI
       REWIND IUNIT
       READ(5,1) IC,IS
C   IC= NUMBER OF CHANNELS
C   IS= NUMBER OF INLET CROSS-SECTIONS
       IF(IC.GT.7.OR.IS.GT.7) WRITE(6,1671)
 1671  FORMAT(///,5X,'***** TOO MANY GRIDS FOR DIMENSIONS',//)
       ICH(NI)=IC
C   READ SECTION AREAS ( ONE CARD PER SECTION)
       DO 5 I=1,IS
 5     READ(5,2) (A(I,J),J=1,IC)
 2     FORMAT(10X,7F10.5)
C
C   READ SECTION WIDTHS (ONE CARD PER SECTION)
       DO 6 I=1,IS
 6     READ(5,2)  (B(I,J),J=1,IC)
C
       ICP1=IC+1
       ISM1=IS-1
C READ LENGTHS (ONE MORE LENGTH PER CARD THAN CHANNELS)
C                ( ONE LESS CARD THAN THE NUMBER OF SECTIONS)
       DO 7 I=1,ISM1
 7     READ(5,2)  (L(I,J),J=1,ICP1)
C
C INITIALIZE VARIABLES TO BEGIN ITERATION
C NUMBER OF GRIDS ALONG THE CHANNEL IS ONE LESS THAN THE NUMBER OF
C CROSS-SECTIONS
 88    IS=IS-1
       ISE(NI)=IS
       ISM1=IS-1
       WRITE(6,3678)  NI
 3678  FORMAT(  /,5X,'SUMMARY OF INLET GRID CHARACTERISTICS',/
      1 15X,'INLET NUMBER',I3)
       WRITE(6,1) IC,IS
       DO 10 I=1,IS
```

```
      DO 11 J=1,IC
      LENGTH(NI)=LENGTH(NI)+L(I,J)/FLOAT(IC)
      A(I,J)=(A(I,J)+A(I+1,J))/2.
      L(I,J)=(L(I,J)+L(I,J+1))/2.
      B(I,J)=(B(I,J)+B(I+1,J))/2.
      D(I,J)=A(I,J)/B(I,J)
      N(I,J)=C1-C2*D(I,J)
      LX(NI,I,J)=L(I,J)
      BX(NI,I,J)=B(I,J)
      DX(NI,I,J)=D(I,J)
      NX(NI,I,J)=N(I,J)
      WX(NI,I,J)=1./FLOAT(IC)
 11   CONTINUE
      WRITE(6,1297) I
 1297 FORMAT(/,1X,(SECTION(,I3)
      WRITE(6,1221) (NUMBER(II),II=1,IC)
 1221 FORMAT(5X,(CHANNEL =(,10I10,/)
C PRINT A SUMMARY TABLE OF GEOMETRIES
      WRITE(6,1971) (A(I,J),J=1,IC)
      WRITE(6,1972) (B(I,J),J=1,IC)
      WRITE(6,1973) (D(I,J),J=1,IC)
      WRITE(6,1974) (L(I,J),J=1,IC)
      WRITE(6,1975) (N(I,J),J=1,IC)
 1971 FORMAT(5X,(AREA(FT2)(,10F10.1)
 1972 FORMAT(5X,(WIDTH(FT)(,10F10.1)
 1973 FORMAT(5X,(DEPTH(FT)(,1X,10F10.2)
 1974 FORMAT(5X,(LEN(FT)(,2X,10F10.1)
 1975 FORMAT(5X,(N(,10X,10F10.4)
 10   CONTINUE
C FIND AREA AND WIDTH AT THE MINIMUM SECTION
      AMINI(NI)=99.E+12
      DO 109 I=1,I8
      AA=0.
      BB=0.
      DO 108 J=1,IC
      AA=AA+A(I,J)
 108  BB=BB+B(I,J)
      IF(AA.GT.AMINI(NI)) GO TO 109
      AMINI(NI)=AA
      BMINI(NI)=BB
 109  CONTINUE
 1110 CONTINUE
C ESTIMATE THE INLET-BAY HELMHOLTZ PERIOD
      CALL HELM(THELM,AB,CORL)
      THTF=T/THELM
      WRITE(6,201) T,THELM,THTF
 201  FORMAT(1X,(FORCING PERIOD=(,F7.2,( HOURS(,
     1/,1X,(THELM(APPROX)=(,F8.2,( HOURS(,/
     1 1X,(TF/TH=(,10X,F6.2)
      WRITE(6,1337) ((J,LENGTH(J),CORL(J)),J=1,NINLET)
 1337 FORMAT(  ,1X,(INLET LENGTH  ADDED LENGTH(,  (/,4X,I2,1X,
     1 F6.1,2X,F6.1))
      T=T*3600.
      CALL RKGS(END,DELT,NINLET,QINFLO,ITABLE,T)
      DELT=END/FLOAT(NT)
      DO 2269 NI=1,NINLET
      HH=HS
      WRITE(6,2268) NI
 2268 FORMAT(//,10X,(SUMMARY TABLE OF HYDRAULICS  INLET(,I5)
      IUNIT=NI+8
      CALL CRIT(NT,DELT,IUNIT,T,NCYCLES)
      IF(IPLOT.EQ.1.AND.NI.EQ.1) CALL PLOTS(IBUF,1000,3)
      IF(IPLOT.EQ.1) CALL GRPHC(ALABL1,ALABL2,DELT,IUNIT,NI)
      IF(IPLOT.EQ.1.AND.NI.EQ.NINLET) CALL PLOT(0.,0.,999)
 2269 CONTINUE
      STOP
      END
```

```
      SUBROUTINE RKGS(END,DELT,NINLET,QINFLO,ITABLE,T)                  INLET
C ROUTINE TO SOLVE A SET OF SIMUTANEOUS DIFFERENTIAL EQUATIONS          INLET
C ADAPTED FROM SCIENTIFIC SUBROUTINE PACKAGE, IBM, 1970                 INLET
      COMMON/NUM1/Y(5),DERY(5),X,NT,IWT,ZETA,HS                         INLET
      COMMON/NUM4/RNK(3,4)                                              INLET
      DIMENSION AUX(8,5),A(8),B(8),C(8),PRMT(5),AMINI(3)                INLET
      NDIM=NINLET+1                                                     INLET
      PRMT(1) = 1.                                                      INLET
      PRMT(2)=END                                                       INLET
      PRMT(3)=DELT                                                      INLET
      PRMT(4) = .1                                                      INLET
      IF(T.GT.36000.) DELTH=3600.                                       INLET
      IF(T.LE.36000.) DELTH=T/9.                                        INLET
      DO 1122 JN=1,NINLET                                               INLET
      Y(JN)=0.01                                                        INLET
 1122 DERY(JN)=0.001                                                    INLET
      Y(NDIM)=0.                                                        INLET
      DERY(NDIM)=1.0-FLOAT(NINLET)*0.001                                INLET
      DO 1 I=1,NDIM                                                     INLET
 1    AUX(8,I)=0.066666667*DERY(I)                                      INLET
      X=PRMT(1)                                                         INLET
      XEND=PRMT(2)                                                      INLET
      H=PRMT(3)                                                         INLET
      PRMT(5)=0.                                                        INLET
      CALL SETEQ(AMINI)                                                 INLET
      IF(H*(XEND-X))38,37,2                                             INLET
    2 CONTINUE                                                          INLET
      A(1)=0.5                                                          INLET
      A(2)=0.2928932                                                    INLET
      A(3)=1.707107                                                     INLET
      A(4)=0.16666667                                                   INLET
      B(1)=2.                                                           INLET
      B(2)=1.                                                           INLET
      B(3)=1.                                                           INLET
      B(4)=2.                                                           INLET
      C(1)=0.5                                                          INLET
      C(2)=0.2928932                                                    INLET
      C(3)=1.707107                                                     INLET
      C(4)=0.5                                                          INLET
      DO 3 I=1,NDIM                                                     INLET
      AUX(1,I)=Y(I)                                                     INLET
      AUX(2,I)=DERY(I)                                                  INLET
      AUX(3,I)=0.                                                       INLET
 3    AUX(6,I)=0.                                                       INLET
      IREC=0                                                            INLET
      H=H+H                                                             INLET
      IHLF=-1                                                           INLET
      ISTEP=0                                                           INLET
      IEND=0                                                            INLET
    4 CONTINUE                                                          INLET
      IF((X+H-XEND)*H)7,6,5                                             INLET
    5 CONTINUE                                                          INLET
    6 CONTINUE                                                          INLET
```

```
      H=XEND-X
      IEND=1
    7 CONTINUE
      CALL SEA(HS,X)
      CALL TPWRTE(NINLET,X,HS,QINFLO,Y,AMINI,RNK,NT)
      IFLAG1=X/DELTB
      IF(IFLAG1.NE.IFLAG2.AND.ITABLE.EQ.1) CALL TABLE
      IFLAG2=IFLAG1
      IF(PRMT(5))40,8,40
    8 CONTINUE
      ITEST=0
    9 CONTINUE
      ISTEP=ISTEP+1
      J=1
   10 CONTINUE
      AJ=A(J)
      BJ=B(J)
      CJ=C(J)
      DO 11 I=1,NDIM
      R1=H*DERY(I)
      R2=AJ*(R1-BJ*AUX(6,I))
      Y(I)=Y(I)+R2
      R2=R2+R2+R2
11    AUX(6,I)=AUX(6,I)+R2-CJ*R1
      IF(J-4)12,15,15
   12 CONTINUE
      J=J+1
      IF(J-3)13,14,13
   13 CONTINUE
      X=X+0.5*H
   14 CONTINUE
      CALL SETEQ(AMINI)
      GO TO 10
   15 CONTINUE
      IF(ITEST)16,16,20
   16 CONTINUE
      DO 17 I=1,NDIM
17    AUX(4,I)=Y(I)
      ITEST=1
      ISTEP=ISTEP+ISTEP-2
   18 CONTINUE
      IHLF=IHLF+1
      X=X-H
      H=0.5*H
      DO 19 I=1,NDIM
      Y(I)=AUX(1,I)
      DERY(I)=AUX(2,I)
19    AUX(6,I)=AUX(3,I)
      GO TO 9
   20 CONTINUE
      IMOD=ISTEP/2
      IF(ISTEP-IMOD-IMOD)21,23,21
   21 CONTINUE
```

```
      CALL SETEQ(AMINT)
      DO 22 I=1,NDIM
      AUX(5,I)=Y(I)
22    AUX(7,I)=DERY(I)
      GO TO 9
   23 CONTINUE
      DELT=0.
      DO 24 I=1,NDIM
24    DELT=DELT+AUX(8,I)*ABS(AUX(4,I)-Y(I))
      IF(DELT-PRMT(4))28,28,25
   25 CONTINUE
      IF(IHLF-10)26,36,36
   26 CONTINUE
      DO 27 I=1,NDIM
27    AUX(4,I)=AUX(5,I)
      ISTEP=ISTEP+ISTEP-4
      X=X-H
      IEND=0
      GO TO 18
   28 CONTINUE
      CALL SETEQ(AMINT)
      DO 29 I=1,NDIM
      AUX(1,I)=Y(I)
      AUX(2,I)=DERY(I)
      AUX(3,I)=AUX(6,I)
      Y(I)=AUX(5,I)
29    DERY(I)=AUX(7,I)
      CALL SEA(HS,X-H)
      CALL TPWRTE(NINLET,X-H,HS,QINFLO,Y,AMINT,RNK,NT)
      IFLAG1=(X-H)/DELTB
      IF(IFLAG1.NE.IFLAG2.AND.ITABLE.EQ.1) CALL TABLE
      IFLAG2=IFLAG1
      IF(PRMT(5))40,30,40
   30 CONTINUE
      DO 31 I=1,NDIM
      Y(I)=AUX(1,I)
31    DERY(I)=AUX(2,I)
      IREC=IHLF
      IF(IEND)32,32,39
   32 CONTINUE
      IHLF=IHLF-1
      ISTEP=ISTEP/2
      H=H+H
      IF(IHLF)4,33,33
   33 CONTINUE
      IMOD=ISTEP/2
      IF(ISTEP-IMOD-IMOD)4,34,4
   34 CONTINUE
      IF(DELT-0.02*PRMT(4))35,35,4
   35 CONTINUE
      IHLF=IHLF-1
      ISTEP=ISTEP/2
      H=H+H
      GO TO 4
   36 CONTINUE
      IHLF=11
      CALL SETEQ(AMINT)
      GO TO 39
   37 CONTINUE
      IHLF=12
      GO TO 39
   38 CONTINUE
      IHLF=13
   39 CONTINUE
      CALL SEA(HS,X)
      CALL TPWRTE(NINLET,X,HS,QINFLO,Y,AMINI,RNK,NT)
      IFLAG1=X/DELTB
      IF(IFLAG1.NE.IFLAG2.AND.ITABLE.EQ.1) CALL TABLE
      IFLAG2=IFLAG1
40    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SETEQ(AMIN)
C ROUTINE TO SEUP THE EQUATIONS FOR THE RIGHT HAND SIDE OF THE EQUATIONS
C MOTION AND TO DETERMINE THE RANK OF THE TERMS IN THE EQUATION OF MOTIO
      REAL L,LENGTH,LIN,LX,N,NX,LF
      COMMON/NUM5/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      COMMON/NUM1/Y(5),DERY(5),X,NT,IWT,ZETA,HH
      COMMON/NUM2/BX(3,7,7),DX(3,7,7),HX(3,7,7),WX(3,7,7),LX(3,7,7),NX(3
     1,7,7)
      COMMON /NUM3/A0,T,ABY,BETA
      COMMON/NUM4/RNK(3,4)
      DIMENSION AMIN(3)
      G=32.2
      DO 220 NI=1,3
      DO 119 I=1,4
  119 RNK(NI,I)=0.
  220 CONTINUE
      CALL SEA(HS,X)
      HH=HS
C FIND THE  BAY AREA
      HB=Y(NINLET+1)
      ABAY=ABY*(1.+BETA*HB)
      QT=0.
C SET UP EQUATIONS FOR EACH INLET
      DO 100 NI=1,NINLET
      AMIN(NI)=99999999999.
      QQ=Y(NI)
      QT=QT+QQ
      IC=ICH(NI)
      IS=ISE(NI)
      LE=0.
      DO 95 I=1,IS
      DO 94 J=1,IC
      N(I,J)=NX(NI,I,J)
      L(I,J)=LX(NI,I,J)
      LF=LE+L(I,J)/(FLOAT(IC))
   94 B(I,J)=BX(NI,I,J)
   95 CONTINUE
      CALL LEVEL
      AS=0.
      AH=0.
      AF=0.
      DO 97 I=1,IS
      AA=0.
      DL=0.
      DO 96 J=1,IC
      DL=DL+L(I,J)/(FLOAT(IC)*LE)
      D(I,J)=DX(NI,I,J)+H(I,J)
      IF(D(I,J).LT.0.) D(I,J)=0.001
      A(I,J)=B(I,J)*D(I,J)+H(I,J)*ABS(H(I,J))/(ZETA*FLOAT(IC))
      IF(A(I,J).LT.0.) A(I,J)=0.001
      IF(I.EQ.1) AS=AS+A(I,J)
```

```
      IF(I.EQ.IS) AB=AB+A(I,J)
96    AA=AA+A(I,J)
      IF(AA.LT.AMIN(NI)) AMIN(NI)=AA
97    AE=AE+DL/AA
      AMINI(NI)=AMIN(NI)
      AE=1./AE
      IF(IWT.EQ.1) CALL WT1
      IF(IWT.EQ.2) CALL WT2
      IF(IWT.EQ.3) CALL WT3
      DO 140 I=1,IS
      DO 139 J=1,IC
      HX(NI,I,J)=H(I,J)
139   WX(NI,I,J)=W(I,J)
140   CONTINUE
      RNK(NI,2)=AE/(2.*LE)*(1./(AB**2)-1./(AS**2))*QQ*QQ
      RNK(NI,3)=G*AE/LE*(HB-HS)
      DO 85 I=1,IS
      AC=0.
      DO 84 J=1,IC
84    AC=AC+A(I,J)
      DO 83 J=1,IC
83    RNK(NI,4)=RNK(NI,4)+AE/(LE*AC)*G*N(I,J)**2*ABS(W(I,J)*QQ)*
     1W(I,J)*QQ/(2.208*D(I,J)**0.33333*A(I,J)**2)*L(I,J)*B(I,J)
85    CONTINUE
      RNK(NI,1)=-RNK(NI,2)-RNK(NI,3)-RNK(NI,4)
      DERY(NI)=RNK(NI,1)
C FIND THE RELATIVE RANK OF TERMS. NORMALIZE BY THE LARGEST TERM.
      XMAX=0.
      DO 101 I=1,4
101   IF(ABS(RNK(NI,I)).GT.XMAX) XMAX=ABS(RNK(NI,I))
      DO 102 I=1,4
102   RNK(NI,I)=100.*RNK(NI,I)/XMAX
100   CONTINUE
      DERY(NINLET+1)=QT/ABAY+QINFLO/ABAY
      RETURN
      END
```

```
      SUBROUTINE TPWRTE(NINLET,X,HS,QINFLO,Y,AMINI,RNK,NT)
C SUBROUTINE TO WRITE HYDRAULIC INFORMATION ON TAPES
      DIMENSION RNK(3,4),Y(5),AMINI(3)
      HOURS=X/3600.
      NT=NT+1
      DO 100 NI=1,NINLET
      IUNIT=NI+8
      V=Y(NI)/AMINI(NI)
100   WRITE(IUNIT) HOURS,HS,QINFLO,Y(NINLET+1),V,Y(NI),(RNK(NI,J),J=1,4)
      RETURN
      END
```

```
      SUBROUTINE LEVEL
C THIS ROUTINE COMPUTES WATER LEVELS THROUGHOUT THE INLET ASSUMING LEVEL
C ARE LINEAR FROM BAY TO SEA
      REAL L,LENGTH,LIN,LX,N,NX
      COMMON/NUM5/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),O(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      DO 20 J=1,IC
      XL=0.
      DO 10 I=1,IS
 10   XL=XL+L(I,J)
      XX=L(1,J)/2.
      H(1,J)=HS+(HB-HS)/XL*XX
      DO 11 I=2,IS
      XX=(L(I-1,J)+L(I,J))/2.+XX
 11   H(I,J)=HS+(HB-HS)/XL*XX
 20   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SEA(HS,TIME)
C THIS SUBROUTINE DETERMINES THE FORCING SEA LEVEL EITHER FROM
C EQUAL-TIME-SERIES DATA (IF AVAILABLE) OR BY SINUSODIAL FORCING.
      COMMON /NUM3/A0,T,AB,BETA
      DIMENSION Y(52)
      NN=NN+1
      IF(NN.NE.1) GO TO 10
      READ(5,1) TDEL,NPTS
 1    FORMAT(34X,F6.2,6X,I3)
      TDEL=TDEL*60.
C READ SEA LEVEL EQUAL TIME SERIES DATA THE FIRST TIME SEA IS CALLED
C IF NPTS IS GREATER THAN 1
      IF(NPTS.GT.1) READ(5,2) (Y(J),J=1,NPTS)
 2    FORMAT(8F10.5)
      IF(NPTS.GT.1) WRITE(6,3) (Y(J),J=1,NPTS)
 3    FORMAT(3X,16F6.2)
      N1=NPTS+1
      N2=NPTS+2
      Y(N1)=Y(1)
      Y(N2)=Y(2)
 10   IF(NPTS.LT.1) GO TO 100
C INTERPOLATE IN TIME
      IT=TIME/T
      XT=TIME-IT*T
       J=XT/TDEL
      J=J+1
      HS=Y(J)+((Y(J+1)-Y(J))*(XT-(J-1)*TDEL)/TDEL )
      RETURN
C DETERMINE LEVEL IF SEA LEVEL FLUCTUATION IS SINUSODIAL
 100  HS=A0* SIN(2.*3.14158*TIME/T)
      RETURN
      END
```

```
      SUBROUTINE HELM(THELM,AB,CORL)
C ESTIMATE THE INLET-BAY HELMHOLTZ PERIOD
C OF THE INLET/BAY SYSTEM (NEGLECT FRICTION)
      REAL L,LENGTH,LIN,LX,N,NX
      COMMON/NUMS/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      DIMENSION CORL(3)
C USE FIVE ITERATIONS TO OBTAIN THE ESTIMATE
      DO 1000 II=1,5
      SUM=0.
      DO 100 NN=1,NINLET
      AMIN=AMINI(NN)
 100  SUM=SUM+AMIN/(LENGTH(NN)+CORL(NN))
      THELM=2.*3.14158* SQRT(AB/G)/ SQRT(SUM)
C ESTIMATE THE HELMHOLTZ PERIOD
      DO 101 NN=1,NINLET
C ESTIMATE THE INLET LENGTH CORRECTION DUE TO RADIATION
 101  CORL(NN)=-BMINI(NN)/3.14158*ALOG(3.14158*BMINI(NN)/( SQRT(
     132.2*AMINI(NN)/BMINI(NN))*THELM))
 1000 CONTINUE
C CONVERT THE HELMHOLTZ PERIOD TO HOURS
      THELM=THELM/3600.
      RETURN
      END
```

```
      SUBROUTINE WT1
C THIS SUBROUTINE WEIGHTS THE FLOW IN EACH SECTION SO THAT FRICTION
C IN THAT SECTION IS MINIMIZED.  THIS MEANS THAT AT EACH SECTION FLOW IS
C ALLOWED TO REDISTRIRUTE ISTSELF THROUGHOUT THE CHANNELS TO MINIMIZE FR
C HOWEVER, FLOW PERPENDICULAR TO THE CHANNELS IS ASSUMED TO BE SMALL AND
C FLOW IS NOT INCLUDED IN THE EQUATIONS OF MOTION.  BY MINIMIZING FRICTI
C ROUTINE GIVES AN UPPER LIMIT FUR BAY LEVEL FLUCTUATIONS AND INLET VELO
      REAL L,LENGTH,LIN,LX,N,NX
      COMMON/NUMS/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      DIMENSION C(20)
      DO 100 I=1,IS
      SUMC=0.
      DO 50 J=1,IC
      C(J)=A(I,J)**2*(D(I,J)**.333)/
     1 (N(I,J)**2*QX(NI)**2*B(I,J)*L(I,J))
 50   SUMC=SUMC+C(J)
      DO 60 J=1,IC
 60   W(I,J)=C(J)/SUMC
 100  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WT2
C ROUTINE TO DETERMINE THE GRID WEIGHTING FUNCTION ASSUMING THAT
C FLOW IN A GIVEN CHANNEL IS THE SAME ALONG THE ENTIRE CHANNEL
C FLOW IS DISTRIBUTED IN CHANNELS TO GIVE A MINIMUM TOTAL FRICTION
C  FRICTION IN THIS ROUTINE WILL BE SLIGHTLY HIGHER THAN IN WT1 AND THE
C IN THIS SYSTEM IS CONSISTANT WITH THE EQUATIONS OF MOTION.
      REAL L,LENGTH,LIN,LX,N,NX
      COMMON/NUMS/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      DIMENSION C(20)
      SUMC=0.
      DO 100 I=1,IC
      C(I)=0.
      DO 50 J=1,IS
 50   C(I)=C(I)+(N(J,I)**2*QX(NI)**2*(B(J,I)*L(J,I))/
     1 (A(J,I)**2+(        D(J,I))**.33333))
      C(I)=1./C(I)
 100  SUMC=SUMC+C(I)
      DO 70 J=1,IS
      DO 60 I=1,IC
 60   W(J,I)=C(I)/SUMC
 70   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WT3
C THIS ROUTINE ASSUMES THAT DISCHARGE IS EQUALLY DISTRIBUTED THROUGHOUT
C THE INLET GRID SYSTEM.  IN GENERAL THIS WILL NOT BE TRUE BECAUSE IT IS
C DIFFICULT TO ACCURATELY DRAW THIS TYPE OF GRID BY EYE AND FLOW DISTRUB
C CHANGES WITH TIME IN MOST INLETS.  THIS ROUTINE IS USEFUL IN GIVING AN
C VELOCITIES AND BAY LEVEL FLUCTUATIONS.
C GRIDS WITH DEPTHS LT 0.01 FOOT ARE ASSUMED TO HAVE NO FLOW
      REAL L,LENGTH,LIN,LX,N,NX
      COMMON/NUMS/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1BMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      DO 2 I=1,IS
      X=IC
      DO 1 J=1,IC
 1    IF(D(I,J).LT.0.01) X=X-1.
      IF(X.LE.0.) WRITE(6,100)  NI,IS
 100  FORMAT(///,5X,( ERROR -- INLET HAS DRIED UP AS INDICATED IN WT3(,/
     1 5X, (INLET=(,I4,(  SECTION=(,I4,///)
      IF(X.LE.0.) STOP
      DO 3 J=1,IC
      W(I,J)=1./X
 3    IF(D(I,J).LT.0.01) W(I,J)=0.
 2    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE TABLE
C ROUTINE TO WRITE A TABLE OF INSTANTANEOUS HYDRAULICS
      REAL L,LENGTH,LTN,LX,N,NX
      COMMON/NUM5/NI,G,NINLET,ICH(3),ISE(3),QB,L(7,7),B(7,7),D(7,7),
     1 A(7,7),N(7,7),W(7,7),V(7,7),Q(7,7),HS,HB,H(7,7),IC,IS,AMINI(3),
     1HMINI(3),LIN,QX(3),QINFLO,ABAY,LENGTH(3)
      COMMON/NUM1/Y(5),DERY(5),X,NT,IWT,ZETA,HH
      COMMON/NUM2/BX(3,7,7),DX(3,7,7),HX(3,7,7),WX(3,7,7),LX(3,7,7),NX(3
     1,7,7)
      COMMON/NUM4/RNK(3,4)
      DIMENSION NAME(4)
      DATA NAME/6HV(FPS)  ,6HA(FT2)  ,6HWEIGHT  ,6HLEVEL
      HRS=X/3600.
      WRITE(6,1) HRS
 1    FORMAT(1X,[--------------------------------[,/
     15X,[TIME, HOURS =[,F8.3)
      DO 100 NI=1,NINLET
      WRITE(6,10) NI,HS,HB,Y(NI)
 10   FORMAT(/,10X,[INLET[,I3,/,10X,[SEA LEVEL,FT=[,F7.2,/,10X,[BAY LEVE
     1L,FT=[,F7.2,/,10X,[DISCHARGE,CFS=[,E10.4,/,2X,[CHANNEL        SECT
     1ION 1          2          3          4          5          6[)
      IC=ICH(NI)
      IS=ISE(NI)
      DO 4 J=1,IC
      DO 3 I=1,IS
      A(I,J)=HX(NI,I,J)*(DX(NI,I,J)+HX(NI,I,J))+HX(NI,I,J)*ABS(HX(NI,I,J
     1))/(ZETA*FLOAT(IC))
      IF(A(I,J).LT.0.01) A(I,J)=0.
      V(I,J)=Y(NI)*WX(NI,I,J)/A(I,J)
 3    IF(A(I,J).LE.0.01) V(I,J)=0.
      IF(J.EQ.1) WRITE(6,50) J,NAME(4),(HX(NI,I,J),I=1,IS)
      WRITE(6,69)
 69   FORMAT(/)
      WRITE(6,50) J,NAME(1),(V(I,J),I=1,IS)
 50   FORMAT(4X,I2,3X,A6,2X,6F10.2)
      WRITE(6,50) J,NAME(2),(A(I,J),I=1,IS)
      WRITE(6,50) J,NAME(3),(WX(NI,I,J),I=1,IS)
 4    CONTINUE
      WRITE(6,59) (RNK(NI,II),II=1,4)
 59   FORMAT(5X,[TEMP ACC=[,F7.1,[ CONV ACC=[,F7.1,[ HEAD=[,F7.1,[ FRIC=
     1[,F7.1)
      VBAR=Y(NI)/AMINI(NI)
      WRITE(6,61) VBAR ,AMINI(NI)
 61   FORMAT(5X,[MEAN VELOCITY AT THE MINIMUM AREA SECTION=[,F7.2,[ FT/S
     1EC[,[  AMIN=[,F9.2,[ FT2[)
 100  CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CRIT(NT,DELT,IUNIT,T,NCYCLES)
C     SUBROUTINE CRIT COMPARES 3 CONSECUTIVE FUNCTION POINTS
C     AND WRITES MIDDLE POINT IF IT IS A CRITICAL POINT
C
      DIMENSION F(3,5),MARK(5),TERM(4)
      DATA MARKA/1H /, MARKB/1H*/
      REWIND IUNIT
      NLINES=0
      TF=T/3600.
      WRITE(6,1009)
      DO 1 N=1,2
 1    READ(IUNIT) X,(F(N,J),J=1,5),(TERM(II),II=1,4)
      DO 100 N=3,NT
      READ(IUNIT) X,(F(3,J),J=1,5),(TERM(II),II=1,4)
      IF(X.LT.-1.0E+10) GO TO 101
      IOUT=0
      DO 2020 IA = 1, 5
      MARK(IA) = MARKA
      IF (F(2,IA) - F(1,IA)) 2012, 2020, 2014
2012  IF (F(3,IA) - F(2,IA)) 2020, 2015, 2015
2014  IF (F(3,IA) - F(2,IA)) 2015, 2015, 2020
C CRITICAL POINT VALUE FOUND
2015  IOUT = 1
      MARK(IA) = MARKB
      IF(IA.EQ.1.AND.F(2,IA).GT.0.) HSH=F(2,IA)
      IF(IA.EQ.1.AND.F(2,IA).GT.0.) T1=X
      IF(IA.EQ.1.AND.F(2,IA).LE.0.) HSL=F(2,IA)
      IF(IA.EQ.1.AND.F(2,IA).LE.0.) T2=X
      IF(IA.EQ.3.AND.F(3,IA).GT.0.) HBH=F(3,IA)
      IF(IA.EQ.3.AND.F(3,IA).GT.0.) T3=X
      IF(IA.EQ.3.AND.F(3,IA).LE.0.) HBL=F(3,IA)
      IF(IA.EQ.3.AND.F(3,IA).LE.0.) T4=X
      IF(IA.EQ.4.AND.F(2,IA).LT.0.) VE=F(2,IA)
      IF(IA.EQ.4.AND.F(2,IA).GT.0.) VF=F(2,IA)
2020  CONTINUE
      DO 2025 IA = 1, 5
      F(1,IA) = F(2,IA)
2025  F(2,IA) = F(3,IA)
      IF (IOUT.EQ.0) GO TO 100
C     IF(X.LT.(NCYCLES-2)*TF) GO TO 100
      NLINES=NLINES+1
      IF(NLINES.GT.150) GO TO 100
      WRITE (6    ,2101)      X,(F(1,IA),MARK(IA),IA=1,5)
 100  CONTINUE
 101  H=NT
      AMPH=HBH/HSH
      AMPL=HBL/HSL
      PHH= ABS(T3-T1)*360./TF
      PHL= ABS(T4-T2)*360./TF
      WRITE(6,1011) AMPH,PHH,VF,AMPL,PHL,VE
      WRITE(6,1111) TF
 1111 FORMAT(  5X,(TF=(,F7.2)
      RETURN
2101  FORMAT (2F8.3,A1,-3PF8.3,A1,2(0PF7.3,A1),
      3PF9.3, A1, 2(F8.3, A1))
 1009 FORMAT(4X,4HTIME,5X,2HHS,4X,6HINFLOW,5X,2HHB,
     1   5X,3HVEL,7X,1HG,/,5X,3HHRS,5X,2HFT,5X,4HKCFS,
     1   6X,2HFT,5X,3HFPS,6X,4HKCFS,/)
 1011 FORMAT(//,1X,(* CRITICAL POINT VALUE(,///,15X,
     1 (WAVE PROPAGATION(,/,15X,(AB/AO(,5X,(PHASE LAG(DEG)   MAX VEL(,
     1//,2X,(HIGH WATER(,2X,3F10.4,/,
     1 2X,(LOW WATER (,2X,3F10.4)
      END
```

```
      SUBROUTINE READIN (X,Y,YFAC,XFAC,X0,XF,INDC,KK,LN,IUNIT)
C     SUBROUTINE TO READ SOLUTION TABULATION FROM FILE
C
      DIMENSION Y(9), YFAC(9)
      DT5=.5*1./60.
      READ (IUNIT)  X, Y
      IF(X.LT.-1.E+10) KK=2
      INDC = 0
      IF (KK - 1) 10, 10, 50
10    IF (X0 - X - DT5) 20, 50, 50
20    IF (X - XF - DT5) 30, 25, 25
25    KK = 2
      GO TO 50
30    INDC = 1
      X = XFAC*(X - X0)
      Y(LN) = YFAC(LN)*Y(LN)
50    RETURN
      END
```

```
      SUBROUTINE GRPHC(ALABL1,ALABL2,DELT,IUNIT,NI)
C
C     SUBROUTINE GRPHC WRITES PLOTTER TAPE FOR GRAPHICAL
C     OUTPUT OF SOLUTION
C
      DIMENSION BL(2), ISYM(5)
      DIMENSION YLABLL(3),ALEGN(3,6),ALABL1(4),ALABL2(4),SYM(3),Y(9),YFA
     1C(9),XX(2000),YY(2000),TT(9,2)
      DATA YLABLL/10HHEIGHTS, V,10HELOCITIES-,8H-FT, FPS/
      DATA ALEGN/10HFLOW (KCFS,10H)          ,3H    ,10HINLET VELO,10HCITY
     1 (FT/S,3HEC),10HBAY LEVEL(,10HFT)        ,3H    ,10HINFLOW     ,10H
     2         ,3H    ,10HOCEAN LEVE,10HL(FT)      ,3H    ,10HLEGEND     ,10H
     3         ,3H    /
      DATA BL/10HOBSERVED B,10HAY TIDE     /
      DATA ISYM/5,4,3,2,1/
      DATA TT(6,1)/10HTEMPORAL A/
      DATA TT(6,2)/10HCCEL       /
      DATA TT(7,1)/10HCONVECTIVE/
      DATA TT(7,2)/10H ACC       /
      DATA TT(8,1)/10HPRESSURE H/
      DATA TT(8,2)/10HEAD        /
      DATA TT(9,1)/10HBOTTOM STR/
      DATA TT(9,2)/10HESS        /
C
C READ INFORMATION TO DIRECT PLOTTING
C
C  FIRST CARD
C  X0 - STARTING TIME OF PLOT (HRS)
C  XF - ENDING TIME OF PLOT (HRS)
C  SCALX - TIME AXIS SCALE IN HOURS PER INCH
C  YL0 - MINIMUM VALUE OF TIDAL HEIGHTS (FT)
C  YL - OVERALL HEIGHT OF PLOT (INCHES)
C  YLSCAL - SCALE OF TIDAL HEIGHTS (FT/INCH)
C  YR0 - MINIMUM VALUE OF FLOWS (THOUSANDS OF CUBIC FEET PER SECOND)
C  YRSCAL - SCALE OF FLOW ( THOUSANDS OF CUBIC FEET PER SECOND/INCH)
C
C  CARD 2
C  YV0 - MINIMUM VELOCITY (FT/SEC)
C  YVSCAL - SCALE OF VELOCITY (FEET PER SECOND/INCH)
C  SCAL - SCALE FACTOR FOR TOTAL PLOT SIZE
C  IQ - NOT EQUAL TO ZERO FOR A PLOT OF INLET DISCHARGE
C
```

```
      IF(NI.EQ.1)
     1READ ( 5,2001) X0,XF,SCALX,YLO,YL,YLSCAL,YRO,YRSCAL,YVO,YVSCAL,  INLET
     1 SCALE,IQ                                                        INLET
 2001 FORMAT(8F10.5,/,3F10.5,I10)                                      INLET
      WRITE(6,2002)  X0,XF,SCALX,YLO,YL,YLSCAL,YRO,YRSCAL,YVO,YVSCAL,  INLET
     1 SCALE,IQ                                                        INLET
 2002 FORMAT(///,5X,[PLOT INFORMATION[,/                               INLET
     1 1X,8F10.5,/,1X,3F10.5,I10)                                      INLET
C DETERMINE SYMBOL SPACING                                             INLET
      LINTYP=.25*SCALX/(DELT/3600.)                                    INLET
      WRITE(6,1215) LINTYP                                             INLET
 1215 FORMAT(1X,[LINTYP=[,I6)                                          INLET
C                                                                      INLET
C     PLOT LEGEND                                                      INLET
C                                                                      INLET
      CALL SYMBOL(1.,-YL/2.-.8,.20,6HLEGEND,0.,6)                      INLET
      DO 20 LN = 1, 5                                                  INLET
      INDX = 0                                                         INLET
      YP=-YL/2.-.8-LN*.2                                               INLET
      LLN=ISYM(LN)                                                     INLET
      CALL SYMBOL(0.,YP+.06,.14,LLN,0.,-1)                             INLET
      SYM(1) = ALEGN(1,LN)                                             INLET
      SYM(2) = ALEGN(2,LN)                                             INLET
      SYM(3)= ALEGN(3,LN)                                              INLET
      CALL SYMBOL( .4,YP,0.1 ,SYM,0.,23)                               INLET
20    CONTINUE                                                         INLET
C PLOT TITLE                                                           INLET
      CALL SYMBOL(3.5,-YL/2.-1.,.21,ALABL1,0.,32)                      INLET
      CALL SYMBOL(3.5,-YL/2.-1.4,.21,ALABL2,0.,32)                     INLET
C PLOT AXES                                                            INLET
      YLO=-YL/2.*YLSCAL                                                INLET
      CALL AXIS(0.,-YL/2.,16HVELOCITY, FT/SEC,16,YL,90.,YVO            INLET
     1,YVSCAL)                                                         INLET
      CALL AXIS(-.8,-YL/2.,11HHEIGHTS, FT,11,YL,90.,YLO,YLSCAL)        INLET
      CALL AXIS(0.,-YL/2.,9HTIME, HRS,-9,(XF-X0)/SCALX,0.,0.,SCALX)    INLET
      IF(IQ.NE.0)                                                      INLET
     1CALL AXIS((XF-X0)/SCALX,-YL/2.,10HFLOW, KCFS,-10,YL ,90.,-YL/2.*YR INLET
     1SCAL,YRSCAL)                                                     INLET
      IF(IQ.EQ.0) CALL PLOT(( XF-X0)/SCALX,-YL/2.,3)                   INLET
      IF(IQ.EQ.0) CALL PLOT((XF-X0)/SCALX,YL/2.,2)                     INLET
      CALL PLOT((XF-X0)/SCALX,YL/2.,3)                                 INLET
      CALL PLOT(0.,YL/2.,2)                                            INLET
      YFAC(1) = 1./YLSCAL                                              INLET
      YFAC(2) = 0.001/YRSCAL                                           INLET
      YFAC(3) = YFAC(1)                                                INLET
      YFAC(4) = 1./YVSCAL                                              INLET
      YFAC(5) = YFAC(2)                                                INLET
      DO 1234 II=6,9                                                   INLET
 1234 YFAC(II)=.003                                                    INLET
      XFAC = 1./SCALX                                                  INLET
60    DO 85 I = 1, 9                                                   INLET
C IF IQ=0 DO NOT PLOT DISCHARGE                                        INLET
      IF(IQ.EQ.0.AND.I.EQ.5) GO TO 85                                  INLET
      COR=YL/2.+(I-5)*0.8                                              INLET
      CALL PLOT (0., 0., 3)                                            INLET
      KK = 1                                                           INLET
      ISUR=0                                                           INLET
      REWIND TUNIT                                                     INLET
```

```
      INDX = 0
65    CALL READIN (X,Y,YFAC,XFAC,X0,XF,INDC,KK,I,IUNIT)
      GO TO (70, 80), KK
 70   IF(INDC.LE.0) GO TO 65
 72   ISUB=ISUB+1
      IF(ISUB.GE.1998) ISUB=1998
      XX(ISUB)=X
      YY(ISUB)=Y(I)
      IF(I.GT.5) YY(ISUB)=YY(ISUB)+COR
      IF(ISUB.EQ.1998) GO TO 80
      GO TO 65
 80   XX(ISUB+1)=0.
      XX(ISUB+2)=1.0
      YY(ISUB+1)=0.
      YY(ISUB+2)=1.
C PLOT CURVES ( DO NOT PLOT IF EQUAL TO ZERO THROUGHOUT)
      IF(YY(ISUB-2).EQ.0.0.AND.
     1 YY(ISUB-1).EQ.0.0.AND.YY(ISUB).EQ.0.0) GO TO 85
      IF(I.GT.5) GO TO 885
      CALL LINE(XX,YY,ISUB,1,LINTYP,I)
      GO TO 85
 885  CALL LINE(XX,YY,ISUB,1,0,0)
      CALL PLOT((XF-X0)/SCALX,COR,3)
      CALL PLOT(0.,COR,2)
      SYM(1)=TT(I,1)
      SYM(2)=TT(I,2)
      CALL SYMBOL(-2.2,COR,0.1,SYM,0.,20)
 85   CONTINUE
C READ PROTOTYPE BAY TIDE (DATA STARTS AT BEGINNING OF PLOT,SAME DATUM)
      IF(NI.NE.1) GO TO 2019
      READ(5,1) TDEL,NPTS
 1    FORMAT(34X,F6.2,6X,I3)
      IF(NPTS.LT.2) GO TO 2019
      IF(NPTS.GT.1) READ(5,2) (YY(J),J=1,NPTS )
 2    FORMAT(8F10.5)
      XX(NPTS+1)=0.
      XX(NPTS+2)=1.
      YY(NPTS+1)=0.
      YY(NPTS+2)=1.
      DO 3 J=1,NPTS
      YY(J)=YY(J)*YFAC(1)
 3    XX(J)=(TDEL/60.)*XFAC*(J-1)
      CALL PLOT(XX(1),YY(1),3)
      CALL LINE(XX,YY,NPTS,1,0,0)
      CALL PLOT(XX(NPTS/2),YY(NPTS/2),3)
      CALL PLOT(XX(NPTS/2),YY(NPTS/2)+.75,2)
      CALL SYMBOL(XX(NPTS/2)+.1,YY(NPTS/2)+.75,.1,BL,0.,17)
 2019 CALL PLOT((XF-X0)/SCALX+4.,0.,-3)
      RETURN
      END
```

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